

Senate Commerce, Science and Transportation Subcommittee on Science and Space Holds Hearing on NASA Human Space Flight Plans

[LIST OF PANEL MEMBERS AND WITNESSES](#)

NELSON:

Good afternoon.

This is an exceptionally important topic. And, I think that buzzer might tell us that a vote is starting.

(LAUGHTER)

No, it is not. It's quorum call. Hallelujah.

We really want to peel back the onion and get into a lot of the specifics of the extraordinary work that you've done, Mr. Augustine. And thank you for the public service that you have rendered to this country over a lifetime; that you have in government and in the private sector.

And then thank you for this unpaid service, enormous public service that you have rendered. And we're looking forward to hearing from you.

And I want to thank the ranking member of the full committee, Senator Hutchison, for coming. And I want to turn to her for her opening comments.

HUTCHISON:

Thank you, Mr. Chairman.

Mr. Augustine, you have come through our country for our country one more time. "The Rising Above the Gathering Storm" report has been really the bible for those of us who want to promote science, education, math, engineers to graduate from our colleges. And we thank you for that.

And now you have done a great study about the future of NASA and space exploration. And I just want to commend you. Know that it was our committee -- it was Senator Nelson and myself who had the space station, United States part, designated as a national laboratory. And we did that because we saw so many funding shortages, and we knew that if we had it designated in

that way that others could come in and do research -- universities, federal agencies, corporations in the future. And in fact that's beginning to happen.

We are just on the cusp now of realizing the capabilities of this enormous investment that we have been making in the International Space Station. And we're just beginning to realize it, and yet now we're beginning to talk about shutting down the shuttles and not being able to fully equip and utilize the space station. And I comment you for the report that says we must utilize it in order to have the investment pay off that we have made in this International Space Station.

But you also pointed out that without \$3 billion, was the suggestion of the committee, that without that increase that we are facing some great shortages, not only in being able to use the space station correctly and allowing it to reach its full potential, but also the gap in our ability to put humans in space for the space station, but also for our national security; will definitely happen unless we are able to put the money in that will do one of the options that you suggest.

I think I can speak for myself and say that I'm hoping that we will be able to extend the shuttle to narrow that gap.

But, I thank you for the effort that you have put in. I will want to ask you questions.

I thank you, Mr. Chairman, for holding this hearing and also, Mr. Chairman, for your complete commitment to NASA and space exploration. Without your commitment and the vigor that you have shown, I think sometimes maybe Congress would have lagged behind in making sure that we are doing what we need to do to stay in the forefront of utilizing space.

So I thank you for calling the hearing. I thank you, Mr. Augustine, for leading the panel. And I will look forward to questions.

NELSON:

And as you give us this report, Mr. Augustine, I think it is going to become increasingly apparent that the moment of truth for the future of NASA's human space flight is here. And as you and others will point out, there's only one person that can lead America's human space flight program, and that is the president. And so the work that your panel has done is in preparation for the president making a decision.

Kay would like to lead it -- I would like to lead the space program, but a senator can't do it. Charlie Bolden, the administrator of NASA can't lead it. The human space flight program of this country can only be led by the elected leader of this country, because he sets the priorities.

So as a result of what you've said, if he is going to be wanting to increase and continue human adventure into the cosmos, he's going to have to pony up, in his Office of the Management and Budget, more money. It has been stated from this dais over and over in the last decade that NASA was not getting enough money to do everything that it was asked to do.

And that is obviously apparent now that we are about to complete the space station and shut down the space shuttle and we don't have the next rocket ready. It's only so if we're going to have a program, it's going to have to be the president. And he's going to have to put the juice to the program.

The second thing is that the president is going to have to articulate to the country the vision of why it is important for us to go beyond low Earth orbit, a subject that your panel has broached, but only the president can articulate. Because a majority of Americans don't even remember when we landed on the moon, and what an extraordinary accomplishment that was.

And so, why do we want to venture out? And only the president can articulate as we move from here, severely underfunded NASA that is way behind the timeline and doesn't have another rocket ready as a follow-on to the space shuttle, to whatever that vision is that the president wants us to go on beyond low Earth orbit, he's going to have to say how we take care of that workforce -- this extraordinary workforce that is so talented and has so much historical memory, and are not all ready to retire.

And the president is going to have to set priorities of how do we not only keep some of them in work and able to get to the vision that I hope the president will articulate, but providing the means on a daily basis.

And, I would hope that when the president lays that vision out, that he's going to tell what NASA has done in 50 years, not only with the extraordinary feats in outer space, but what has happened here on the face of planet Earth as a result of America's space program.

The technologies that have been developed in health and medicine and transportation and public safety, and the lifestyles that we live better in our home and at the office as the result of NASA spin-offs in micro-miniaturization and what it's done for the environment. And that's not even to speak of what it's done for computer technology and industrial productivity.

You can say it till you're blue in the face, I can say it, Administrator Bolden can say it, but the American people are going to listen only to the president.

And what you've laid out is a blueprint, a menu for the president to make choices. And, it is my fervent hope that he's going to say we're going to put the juice to it, we're going to have a vision that we're going beyond low Earth orbit, and in the process we're going to nourish that work force so that we have them ready when we do the next huge leap for mankind.

Senator Vitter?

VITTER:

Thank you, Mr. Chairman, for convening this really important hearing.

And, thank you, Mr. Augustine, for all of your work and the work of your committee. It's very, very important. You've undertaken a big challenge and we appreciate all of your service and those of your committee members.

I'll look forward to reviewing the full file report when it's available, but I appreciate the summary and your testimony today. And, as you can tell, we thought it was important to start this discussion in earnest sooner rather than later. So that's what today is about and I appreciate your being here.

You've made it really clear and underscored what so many of us have been saying, that the funding profile for the exploration program has been inadequate and it would be virtually impossible to sustain under the flat line out-year funding profile that was included with the original 2010 request. And, I think that's one key point that all of us want to underscore and amplify.

Our other challenge, of course, is to clearly what the nation's human space exploration policy should be, what programs and tools we need to implement, and exactly what financial resources are required to make it all work. Another of the key messages of your committee, I believe, is that if we intend to have a viable human space exploration program in this country, we're going to need to step up to the plate and provide funds necessary to make it work. And, that's a big part of the discussion.

And that's important because I believe one of the key elements of our decisions must be having a path forward that makes it possible to retain our highly skilled work force, and not lose so much of that human capital, and to sustain more broadly our aerospace industrial capacity. A lot of that is human, but it has other elements as well.

So I look forward to exploring all those key issues with you and thank you again for your work.

NELSON:

Mr. Augustine, as we discussed earlier, your written testimony will be submitted in the record, and you're going to share for us in a brief way some of your comments so we can get right into the questions.

I just want to say for our audience that Mr. Augustine has quite a pedigree. He's been a research engineer. He's been a program manager. He's served in government in the Office of the Secretary of Defense, assistant director of defense research and engineering. He was the assistant secretary of the Army; became acting secretary of the Army. And then he has served in academia on the faculty of Princeton.

He's, obviously -- everybody knows him as the former CEO, and then he's got every advisory committee in the world that he's been on.

So, Mr. Augustine, with that pedigree, indeed, we are honored that you are here.

AUGUSTINE:

Mr. Chairman, thank you very much -- Senator Hutchison, Senator Vitter and the members of the committee. I appreciate this chance to appear on behalf of my colleagues on our committee and describe to you some of our results.

And I will submit for the record my prepared statement and briefly summarize it now.

You provided the proper opening, and that is the human space flight program in America is at a tipping point right now, probably more so than at any time since President Kennedy took the leadership to say that we should have such a program.

Before I begin, I would like to acknowledge the enormous effort and dedication of the members of the committee with whom I had the privilege of serving. I've rarely worked with a group who put in the hours and the effort that this group has.

I also would like to take note of the fact that we -- the support we received from NASA was extraordinary. Extremely competent people, very open and candid, very hard working and very responsive.

Further, we had hired as a committee the Aerospace Corporation to work for us as a committee independently to provide us with a separate view of the programmatic issues, technical issues, cost issues, schedule, so on. And, they too have been all we could have hoped.

As you know, our committee consists of 10 members; was broadly constituted. It included scientists, engineers, educators, former business executives, astronauts, a former Air Force general officer, former presidential appointees, and so on, all with a background in space.

We were given only 90 days for our effort, the reason of course being to try to match it to the budget cycle. That was not a great deal of time to address such a difficult issue. On the other hand, our members didn't start from zero. We did have some background.

But, I call that to your attention because as a caveat, there are limitations of what we were able to do, and the committee should have that in mind as you review our work.

Our committee -- and I need to really emphasize this -- was asked to provide options, not to make a recommendation. And, that's very important because we tried to abide by that and to be very balanced in our assessment of the options.

We have not endorsed any particular option. We have said that it seemed clear to us that the ultimate destination for the next step -- major step -- in America's human space flight program is a human landing on Mars. We have concluded, reluctantly and with some disappointment, that in our judgment it would not be safe to attempt such a mission at this point in time.

In other words, we have concluded that the direct to Mars mission is not something that our nation ought to undertake for safety reasons, let alone the financial impact that that would have.

The various parameters we looked at -- made it possible to define over 3,000 options that we could have offered to you. We tried to narrow that down for obvious reasons, and have narrowed it to about -- or to specifically five families. And I say "families," because it's possible to move an item from one family to another and to adjust the results if people want to do that. But they're representative families, we believe.

One member of that family is the existing program as it's being pursued today by the nation through NASA. Let me define for you what we consider what we consider to be the existing program. It's the program that's the basic NASA plan that NASA has provided, and it's the budget that we are given by the Office of Management and Budget.

I won't describe to you the other four integrated options. You have them available, I'm sure. And I'll be pleased to address them at any time you'd like. But to save time now I won't do that.

Our committee -- the bottom line conclusion to which we arrived, a disappointing one frankly, is that pursuing that existing program is really not executable and will not lead to a satisfactory outcome for America's human space flight program.

The reason for that is the mismatch of goals and funds. There's more work to do (inaudible) and I support to carry out that work. That's always dangerous, but it's particularly dangerous in hazardous undertakings like human space flight.

If we were to continue on the path of the existing program, which is one option, certainly we could do that, let me cite what a few of the outcomes would be. The first is that we would have to launch six shuttles in the next 12 months. One can question whether that would be a safe thing to have to do.

Secondly, that there will be no funds to enhance the existing technology program to provide the basis for the successful program in exploration later. In addition, there will be no substantial funds to make use of the space station during the next five years so that it would be in orbit.

Thirdly, we would have to de-orbit the space station in a little over five years from now, after having spent over two decades building the space station and putting some 900,000 pounds into orbit. We would the complete the development of Ares and Ares I, in the committee's judgment, two years after the space station would have been splashed into the Pacific Ocean. Of course, one of the main reasons for Ares I was to support the space station.

The heavy lift launch capability, which is the thing this nation really needs to get out into space, would be delayed until the mid to late '20s because of the lack of funds. And when we finally got the heavy lift capability, based on Ares V or whatever, there would be no upper stage to put on it, nor any lunar surfaces to use it. And so, we're looking at the mid-'30s in this case, before we would be able to do any real exploration, in our judgment.

And that basically is the path that we're on. Our committee has offered other options that could give us a very exciting program: a program that lets us, for example, circumnavigate the moon again, circumnavigate Mars, land on one of the moons of Mars, to land on or dock with an asteroid, to visit one of the Lagrangian points, with the large number of events over the next 15 years.

The problem with all the other programs that we've offered, the only programs that we've been able to find that we think are viable, is that they require, roughly speaking, an additional \$3 billion per year to carry them out. And absent that additional funding, I'm afraid our nation's in a position where human space flight substantially goes on hold.

We could develop launch vehicles. Yes, we can do that. We can do a little technology, but there will be no really significant human space flight work. And the ISS, International Space Station, will come to an end five years from now.

I would like to close with just three observations. One is that we've intentionally been relatively conservative in our estimates of cost, schedule, performance. We do that, frankly, to reflect our dissatisfaction with our record as a profession in that area in the past.

Secondly, we believe that not only are we in a current situation where ends don't match means, or means don't match ends, but we believe NASA's been in that position for decades and it's time that we take NASA out of that position. NASA is a national asset, and it's unfair to the people of NASA and, we believe to American citizens, to continue in that circumstance. Indeed, if we have to change the objectives to fit the means, so be it.

And then lastly, that as this committee would know so well -- and Mr. Chairman you would -- human space flight inherently involves risk. We should do all those things we can possibly think of to make human space flight safe. And, indeed, we've tried to propose those things. But at the end of the day, there still remains a non-trivial safety risk. And any nation that hopes to be a space-faring nation has to face up to that situation.

And, finally, I will conclude by thanking the administration and you for the trust that you've put in my colleagues and myself to address an issue that affects what really is one (inaudible).

And with that, Mr. Chairman, I'd be happy to address your questions.

NELSON:

And since we have a vote and have five-and-a-half minutes left, we will recess the committee and we will come right back and we'll get into the questions.

Thank you. The committee is recessed.

(RECESS)

NELSON:

The committee will resume.

Please excuse the interruption, but we were able to get two votes done on the floor.

So let me turn to Senator Vitter.

VITTER:

Thank you, Mr. Chairman.

Mr. Augustine, upon finding it impossible to identify a viable program with the out-year budget that we have now, your committee suggested an annual increase of roughly \$3 billion in NASA's top line adjusted, by inflation, in future years at 2.4 percent. Can you give us a general sense of how you all arrived at those numbers?

AUGUSTINE:

Senator, I'd be happy to do that.

We first of all analyzed the budget we were given by OMB, which is today's baseline of course. We then ran excursions. The first excursion we ran was one that built up from today's budget to a \$3 billion add-on by 2014, and then it goes up to 2.4 percent.

We ran an excursion of \$1.5 billion and found that it really made little difference as compared with the baseline case. We ran an excursion at \$4 billion and it gives you somewhat more latitude for financial conservatism, if you will, than the \$3 billion case. But it doesn't let you do anything significantly new.

So, from the various cases we ran, the \$3 billion run-out at the 2.4 percent inflation rate seemed to give us a very sound program.

VITTER:

OK. One of the consistent points that's been made up to now about the retirement of the shuttle is basically that you take those funds and shift them over to next generation. And that's really always seemed to be the rationale for the whole idea of a clear retirement date for the shuttle. Your committee seems to arrive at a very different conclusion in terms of the actual amount of financial wedge that would bring about. Can you describe the difference, the very different conclusion, how you reached that very different conclusion?

AUGUSTINE:

Yes, of course. First of all, our committee believes that we need to fund enough in 2011 to continue shuttle launches through the first six months, so that we don't have this compression of launches and pressure that tends to build up - sometimes called launch fever in the vernacular.

The committee -- let's see, I lost my train of thought. Begin -- the question?

VITTER:

The ideas, how -- explain the very different conclusion that you all reached versus the mindset of stopping the shuttle by a more or less date certain, and then being able to shift that money to next generation.

AUGUSTINE:

All right. The common thinking up until now has been that stopping the shuttle would free a substantial sum of money that you say would let you do exploration in the future. But there's some offsets that one has to consider that I think probably haven't been considered in the past. One of those offsets is that if you were to continue the shuttle operation you would not presumably have to pay for the rides on the Russian launch vehicle. And so there's an offsetting saving.

In addition, as one looks at the costs of operating NASA, much of the overhead today gets billed to the space shuttle program just because of the way the books are accounted for at NASA. And so, if the space shuttle program stops, unless you make a major cut in NASA's overhead, and by overhead, this chair -- I should say fixed costs rather than overhead -- unless you make a major cut in fixed costs at NASA, then you have a situation where those costs have to be transferred somewhere, and the likely place for them to be transferred would be the Constellation program. And so there's not really a saving, there's just a bookkeeping shift.

And when you go through these various nets and a few more minor things, it looks like the savings by shutting down the shuttle at a fairly hard stop is on the order of \$2.5 billion a year, which is significantly less than some of the numbers that others quote.

VITTER:

OK. I think I understand your reasons for saying that. As of now we shouldn't plan on more as the way -- going to Mars in the way that's been described. We can't do it safely in that way, based on our knowledge now.

My concern is that the way that will be interpreted is to basically take Mars off the table, and in doing so, suck most of the oxygen out of the room in terms of general interest in manned space flight.

And to the average guy on the street, we're going to spend all this money redoing what we've already done, what's sort of the point in that? Do have a reaction to that concern about the public discussion and how that would be interpreted, or the sort of overarching political reaction to it?

AUGUSTINE:

We very much shared that exact same concern, and discussed it at some length. The report, when it's released, I think you find makes a great -- puts a great deal of emphasis on the fact that Mars is to be the destination that we're aiming at. And that there's some homework that has to be done on the way to Mars, and that homework includes such things as the effects of long term zero Gs on humans that then go into a less than 1G environment; the effects of galactic cosmic rays on humans, information you can't get from the space station; various operational things that one might need to do to go to Mars.

And so our message has been to make very clear that Mars is still the goal, but we're just not ready to go directly there today. But we do intend to get there.

VITTER:

Well, I would really underscore that concern. And, again, I'm not arguing with your either analysis or whatever you intend to communicate. I'm arguing about how it may come across. Let me go at the same issue another way.

What, short of Mars, in this list of possibilities is there that is new and different and that can really excite a lot of people that we haven't done before?

AUGUSTINE:

To the point of your question, we defined a flexible path option. And if you happen to be following (inaudible) our report, it's the, I think, option 5. And a concern we had even if you were to set out for Mars today, you would have about a 15-20 year period during which we don't get to Mars, and how you hold the public interest when you say send money and in 20 years we'll put a flag on Mars.

So we tried to define a program called this flexible path program that has intermediate milestones where as you go along you could have things that not only engineers could point to, but the average citizen would look at and say was significant.

And we think those intermediate milestones would include -- most straightforward of which is circumnavigating the moon. Another is possibly landing on the moon, although we don't think that's mandatory. Another would be to circumnavigate Mars -- with humans I'm talking about. Another interest would be to dock with an asteroid and not only for the scientific interest, but to get to learn how you conduct operations like that. And should someday we find a large asteroid flying in the direction of the Earth, it would be nice to know how to dock with it, what they're made of and so on, the role that humans might play.

And then there's the possibility of landing on a Mars moon, Phobos or Deimos -- Phobos or Deimos with the notion that not only would that be an interesting place to land from a scientific standpoint, it's also interesting in terms of helping conduct robotic exploration of Mars. The presumption that our committee has is that well before we go to Mars with humans, we would send additional explorers there.

But there's -- it's relatively difficult to operate a robot on Mars, in part because of its time transit -- transit time -- for communications even at the speed of light, you're talking about tens of minutes to get a signal out and get a signal back, depending where you are in the orbit. And with that it's very hard to operate a rover or something on Mars.

But the notion has been put out that if you had astronauts on one of the moons where the transit time with the surface of Mars is very small, that the astronauts on moons could operate explorers on the planet and learn a great deal before you committed a human to landing on the planet Mars.

This is a much easier task probably know, because if you think of -- the scientists talk about space as having gravity wells in it, that once you get into one of those wells it takes a lot of energy to get out of it -- you're probably familiar with this. And the Earth has a very deep gravity well. Mars is a deep gravity well. And the moons of Mars are quite shallow. And so it offers a nice promising approach.

Another place of interest is what are called the Lagrangian points that are points in space when you have two large bodies and a small body, or three bodies, where that point, if you put a space craft there, it will essentially remain fixed in that relative position to the two large objects, in this case the moon and the Earth. And some of those points are stable in the sense that if you put a space craft there it'll stay there. Others, it'll very slowly try to drift away and you have to push it back.

Those points are interesting to put telescopes, are interesting for refueling stations, filling stations in space. And we can fly to one of those.

So it's our belief there are a lot of exciting things that one could do along the way.

VITTER:

OK, thank you.

Mr. Chairman, I have several other questions, but let me defer to someone else for now.

NELSON:

Mr. Augustine, right out of the box the president is going to have to answer the question whether or not the cost of human space exploration is worth it.

So I think, as I said at your opening hearing in Washington months ago, that the report of your committee is going to be very decisive in influencing the White House.

Why don't you just state for the record what your committee feels about the cost of human exploration being worth it?

AUGUSTINE:

It's a question that we obviously addressed and one that I wished I could provide a good answer better than I'm able to. And the reason I say that is that our committee wasn't in a position to compare -- it's a question that says where would you spend that money? There are other places you could spend it. And we don't have background in health care, we don't have background in many of the other things that you -- you face.

So I will try to answer the question with that caveat, that really is only the president and perhaps yourselves who can make that judgment.

We think that the argument about human space flight being worthwhile, because, for example, of the science it gathers, has been an unfortunate argument to make because we don't think you can justify human space flight based on the cost of it, based upon the benefits it gives to science.

Nor do we think you can justify it purely on the basis of the impact on technology or the impact of education. All those things are important. It indeed has a positive impact.

But we think we have, to put it very bluntly, trapped ourselves by trying to justify human space flight because of the benefits to science or what have you.

We think the justification has to be an intangible justification. It's a justification that says the purpose is to prepare a path that will put human beings into the solar system, which shows American leadership, the benefits of the American system, the leadership of our technology. It provides inspiration to our students, to our young people to go into math and science. It can have the kind of an impact that the Apollo 11 had during a time of some travail in our country.

These are intangibles, but we think they're not unimportant. We think they are important. And we don't diminish or minimize these other benefits. They're real, they're there. But they by themselves probably don't justify a human space flight program.

The question -- I'll stop in a moment here, Mr. Chairman. The question, of course, arises, perhaps should you spend money on human space flight or on cancer research? I would argue that that's an unfair question. We live in a nation where we spend \$7 billion gambling on the Super Bowl last year. We spent \$32 billion on videos and going to the movies. We spent, I think, \$65 billion on illegal drugs.

So it's clear to me that this nation can afford -- I'm speaking for myself now -- it's clear to me that this nation could afford a strong human space flight program. It's simply a question of priority.

NELSON:

As your committee discussed these intangible benefits, no doubt you noted also some of the tangible benefits. What do you think they are, as we continue to push forward?

AUGUSTINE:

Let me take the International Space Station as an example, if I may. We spent over two decades constructing the ISS and we now are talking about using it for only five years. During those five years we don't have much money available to pay for the science that would produce these tangible benefits.

There at one point was a large number of scientists who wanted to conduct science on the station. They've somewhat dwindled away because of the slips in the program and the lack of funds.

Given funds there's significant microgravity to be done. There's significant biosciences work to be done. We've done some amazing things in terms of technical operations. Extra-vehicular activity has become -- I'm not going to use the word almost routine -- but it's certainly more common. We know to do that. We know how to dock routinely. And there are benefits like that.

And then in addition, there are always the spin-offs that one gets where you develop technologies for the space station or for other things in space that impact commercial products.

NELSON:

Senator Hutchison?

HUTCHISON:

If I understand correctly, and you correct me if I'm wrong, yesterday in the House you indicated that if adequately funded, the Constellation program currently under way is a good

program. And coupled with the shuttle flight continuation until a replacement human-rated capability is developed, either to Ares or commercial vendors, that the gap in human space flight could be closed and the International Space Station support and utilization could be ensured.

Is that your view? And is, in your view, the \$3 billion with the cost-of-living, or 2.4 percent increases per year, would be adequate for that kind of approach?

AUGUSTINE:

Yes, let me try to be clear. It would not be our view that you could conduct that kind of a program with the existing budget. It would be our view that with the \$3 billion inflated profile, that you indeed could conduct such a program. And as you know, there are no funds to take the ISS in the current program beyond 2010 -- excuse me, 2015, the shuttle 2010.

HUTCHISON:

And is it also your view that the Constellation program together with an extension of the shuttle flight program would be a good approach to closing the gap and utilizing the space station?

AUGUSTINE:

We looked at a lot of options to try to close the gap. And it's our view that the gap is likely to be more like seven years instead of the five years that people have talked about. The only option we can find, viable option, to close that gap is to continue to operate the space shuttle. To do that, one of course has to commit funds to the shuttle which otherwise could be spent on the exploration -- preparing for the exploration program.

And one would certainly have to re-certify the shuttle to be sure that the safety issues were taken care of. But to answer the question, not only is the shuttle a way to close the gap, it's probably the only way to close the gap.

HUTCHISON:

Do you think that option is an acceptable -- I know you didn't pick a recommendation, but that that would be an acceptable option?

AUGUSTINE:

It's a viable option, yes.

HUTCHISON:

And then, on the safety issue, do you believe that the Columbia accident investigation recertification standards are adequate? And if those were continued to be met, that that would -- and you can never ensure safety, because you never know all the factors, but that that too would give us a solid safety shuttle for continuation for as much as you can ensure?

AUGUSTINE:

Yes -- and I appreciate your qualifying that. One of the frustrating things to an engineer like myself is that 90 percent of the liability failures that we encounter -- and I separate that from safety -- but 90 percent of them come from causes that aren't even in our models.

There are human error, they're a design flaw. And so, with that caveat it is our belief that were NASA to complete those requalification steps, that we could continue with reasonable safety. We base that partly, of course -- one of our members, Dr. Sally Ride was a member of that Columbia and also the Challenger failure evaluations. But it is our belief that that could be done.

HUTCHISON:

OK. On the issue of the commercial development, I have been certainly a supporter of the COTS, the Commercial Orbital Transportation System. I think that is a viable area for -- for private investment and also for a kind of a fallback position where we need it.

But I do want to ask you if we have that private capability, but not the Orion or the Ares ready to go, and we still have the gap in our own NASA capability, do you think that exclusive reliance on the commercial development is justifiable in the -- in the face of the need to utilize the space station, or does that concern you?

AUGUSTINE:

The reason we offered options that depend heavily on commercial development are that we're trying to free NASA's money and talent to tackle the tough problems of going beyond Earth orbit, rather than running a trucking service to Earth orbit. We think we're in a situation rather like the airlines were when the government stepped in and awarded contracts to carry the mail. That was the thing that made the airlines viable. And today NASA has and NASA is pursuing this opportunity that you describe.

It certainly bears risk. Many of the firms that are involved have not built major launch systems. In our evaluations, we were particularly conservative in assessing their capabilities.

For example, some of them claim that they can have vehicles ready within three years. We think it's more like six years. But certainly there's no reason that these companies can't produce a viable capability, given the support of NASA

HUTCHISON:

And would you be comfortable that they could provide that service if there is a gap, and that that is reliable enough?

AUGUSTINE:

I think the answer is yes. But, fortunately, we don't have to answer that at this moment. But there are other alternatives available, including French-launched vehicles, continue to use the Russian-launched vehicles, none of which are attractive to me as an American, although I believe in international programs. And I believe that if you're going to have international programs that are meaningful, we're going to have to get used to having other nations on the critical path.

At the same time, there is no more critical path, I think, than being able to carry astronauts to lower Earth orbit. And that might be the one exception where I think we should have a capability. So my answer is there is risk, non-trivial risk, but (inaudible) our mind it's a risk worth taking.

HUTCHISON:

Thank you.

Thank you, Mr. Chairman.

NELSON:

Now, following up Senator Hutchison's question on the commercial, you're really looking at the cargo capability on commercial, because that next step of the question of safety for human capability, what did your committee come up with on that?

AUGUSTINE:

It would be our recommendation that as NASA develops new launch vehicles, most new launch vehicles, that it would make arrangements so that they could be human rated at the appropriate time. And so we think it would be wise to begin addressing how would you human-rate those commercial vehicles?

NELSON:

And did your committee have a time at which you think that they might be ready for human-rated commercial vehicles?

AUGUSTINE:

I think, Mr. Chairman, I better provide that for the record. We did evaluate that. I can't remember the time. It's not within the next six years or so. But I will provide that for the record.

NELSON:

Senator Vitter?

VITTER:

To directly follow up on that, is that to say that you would agree with ASAP in their '08 report that it's unlikely that COTS would be done in time, human-rated, to minimize the gap?

AUGUSTINE:

That's our view.

VITTER:

OK. Going back to the gap and extending the shuttle, if you extend the shuttle at least slightly into 2011, as you've talked about, simply to ensure that there's no launch fever, but not beyond that, and you accept a gap, versus extending the shuttle beyond that to close a gap, how much do you -- let me put it this way. How much do you sacrifice in extending the shuttle beyond that to close all the gaps in terms of pushing for next generation activity?

AUGUSTINE:

I'm doing this calculation mentally, but it would probably be about \$18 billion over -- to close the gap by using the shuttle, would be the incremental cost.

VITTER:

And what does that translate into time in terms of otherwise using it to pull next generation forward?

AUGUSTINE:

Well, I guess the way I would characterize that would be if it would let you go in (inaudible) \$3 billion profile for six years. These are not precise numbers, Senator Vitter -- but which I think the most important thing it's not so much the time it pulls forward, but when you reach these big milestones of having new launch vehicles, you would have money to have -- develop things to put on top of them that go somewhere.

VITTER:

Wouldn't you also presumably develop the new launch vehicles at least somewhat sooner?

AUGUSTINE:

If you use that money, you would probably be able to accelerate the launch vehicle some, but I don't think it would be -- you would certainly, if you spent the money for example on the Ares V, you could clearly draw it forward. I don't know the amount, but probably significantly.

VITTER:

I'm not asking for a yes-no answer. How would you suggest we analyze that difference? In other words, extend the shuttle and close the gap, versus accept a gap, try to minimize it, but be able to use that money toward where we're ultimately going.

AUGUSTINE:

We did do that analysis and we'll provide it. It was our conclusion that continuing the shuttle to close the gap is a viable option, and it's one of the options we offered. I'm trying very hard not to make a recommendation here. But it -- one runs into the problem that the more money you spend in the near term, the less you can do in an exploratory program. So to us the cost of continuing to operate the shuttle is quite high.

VITTER:

Well, that's where I was going. So you'd certainly agree with my reaction to those figures that that's a lot of money...

AUGUSTINE:

Indeed.

VITTER:

... to continue the shuttle?

You know, I represent Louisiana, which includes (inaudible). I'm all for the external fuel tanks. But my concern is once you start putting off the next generation that much, you threaten ever getting there and you threaten really building a consensus and a reality that people think we're ever going to get there, and so we don't.

Do you have a reaction to that?

AUGUSTINE:

You know, I think you're coming back to the fundamental problem of NASA, and that is that with the budget constraints it's had on it, it doesn't have enough money to develop the next generation system while it continues to operate the current system. And so the consequence of that today is the gap with which most of us are not particularly happy.

And there will be another problem that when we complete the Ares I there will be another gap. What are we going to do with the Ares I and the Orion once we get them? And when we complete the Ares V there will be no lunar excursion module, if you will, lunar lander, nor a surface system to use it. So this may be just the first of three or four gaps.

VITTER:

So just to be clear, this concern of mine in terms of tradeoff isn't solved by the extra \$3 billion? I mean, that mitigates it, but that tradeoff is still there even at the higher funding levels you're talking about?

AUGUSTINE:

The programs we have, the add-on the \$3 billion, one of them includes the shuttle and it has the problems we've just discussed. The other ones do not include the extension of the shuttle beyond mid-2011.

VITTER:

OK. That's all I have right now, Mr. Chairman.

NELSON:

I want to ask a series of questions around the major themes of your report. The fact that if we're going to have a robust human space program, that it's going to -- we're going to have to commit the resources to it. You specifically talked about \$3 billion a year.

Your architecture is various and engineers such as yourself and NASA leadership are going to have to determine that architecture, but the goal that the committee has set is to get out beyond low Earth orbit; that NASA ought to be exploring the heavens with the human space program. And that in the meantime, we've got to worry about the workforce.

So I want to pick up on those three themes, which I think are going to be the major themes that the president is going to have to make his decision on.

Now, you came up with this idea of \$3 billion a year. If you had additional resources, what would you do?

AUGUSTINE:

Beyond the three billion? The primary things that we think need to be done in the near future are largely covered in the \$3 billion figure. If you had additional funds, you would probably be able to move forward somewhat, some of the -- some of the work on Ares I. But I think it would be a modest amount, but you could accelerate that.

You could clearly move Ares V forward, or an alternative Ares V, which would be very important, because that really is the long pole in our space exploration tent.

NELSON:

Is the Ares V?

AUGUSTINE:

Is the heavy lift capability...

NELSON:

Heavy lift capability .

AUGUSTINE:

... is a good example.

NELSON:

So you have come up with a robust human space flight program in the near term without having to shortchange other missions in science and aeronautics?

AUGUSTINE:

We believe that's true. We, of course, assume good management of that additional money, which there's every reason to believe we would have. And we've also proposed creating a firewall between the human space flight funding -- and I emphasize funding not technology or mutual support -- and the science program. Because as we all know, the human space flight program is so large that when it has problems it tends to cannibalize the science program.

NELSON:

Do you feel that NASA, in order to maintain the most robust human space flight program -- do you feel like that the realities of this gap are unavoidable. And the fact that we are going to have this gap, with that \$3 billion that you can keep things going by developing the new technologies on down the line?

AUGUSTINE:

To eliminate the gap, or significantly reduce it, would have a significant negative impact on the long term exploration program. I think the gap is something that we're presented with based on decisions that were made in the past -- perhaps good decisions, I don't know. But I think that we're to a considerable degree stuck with a gap.

NELSON:

Did the committee look at taking the Constellation program, as it has been defined and see how much it would cost to execute the Constellation program?

AUGUSTINE:

We did. And, this \$3 billion profile that's added permits either the Constellation or several other options to be carried out. So the answer is we did, and it can be done.

NELSON:

But according to one of your charts, which we can show up here, and what you call the less constrained budget, the first one under the "Moon First Operations" -- right in the middle of the page -- the less constrained, or in other words the \$3 billion additional each year. With Ares V as the heavy launch and with Ares I and Orion as the crewed ALEO (ph), which is the Constellation program as envisioned now -- under that funding scenario, lo and behold, the space station's going to go in the drink in 2015.

So your committee also said that's unacceptable. I happen to agree with you. I mean, why would we spend \$100 billion building the space station and then put it in the Pacific.

But that's what the funding profile is for that \$3 billion, and with an extension of Constellation, is it not?

AUGUSTINE:

Yes, and I think you're -- I can't see that chart, but I think you're referring to option 3?

NELSON:

Option 3.

AUGUSTINE:

And, option 3 was intended to take the baseline program of record and apply a less constrained budget to it, just as we did in the other cases. And the program of record, as you say, splashes the ISS in early 2016 -- completes the flights of the U7 (ph) in 2015.

NELSON:

Well, how is it with what you call the constrained budget, which is the present inadequate, I will say, OMB budget -- I will not ascribe that to the president, ...

AUGUSTINE:

Nor me, I hope.

NELSON:

... but in the so-called constrained option -- and yes, what you just said I think is very important. What you just said, "I hope," from your lips to the president's ears. Option number one, constrained. You could that. No \$3 billion extra, you're still putting the ISS in the ditch in 2015, and you've got Ares V and Ares I.

So what are you buying extra from option 1 to option 3? In option 3 you're getting an additional \$3 billion.

AUGUSTINE:

Option 1 is the program of record, of course, for the current funding. And with that you basically get launch vehicles with nothing to put on top of them. I'm oversimplifying here, Mr. Chairman.

With option 3 you are able to develop the Ares V at an earlier time, you are able to carry the International Space Station for an additional five years.

We've also provided the full amount of money one needs to de-orbit the International Space Station in that option. And one gets a technology program that's rather substantial to begin laying work for the exploration program. And one gets a funding to carry out science on board the -- science and technology -- on board the ISS over that 10-year period.

NELSON:

And I think that's the answer. It is the additional science and technology that you get under that. But let me just point out that the chart -- and maybe the chart needs to be refined before your final report comes out. Option 1 and three are a difference of \$3 billion, and yet it looks like they present the same result because in option 3 you are putting the space station in the Pacific in 2015 under this.

The difference with option 4 is that you have replaced Ares I and Orion with a commercial vehicle to get to low Earth orbit.

AUGUSTINE:

Your point is a very good one. This chart is somewhat misleading in that regard. And there's also the matter the dates change when things become available. For example, under option 1 you're probably in the 2030s when you can conduct human exploration missions. That's our view. It's not necessarily NASA's view. And whereas, under option 3 you could do it considerably earlier.

NELSON:

Since we have a consensus of opinion that we need to get NASA out of LEO (ph), do you have a preference on the architecture? I know you said you're not in the business of recommending a specific course, but do you have any personal feelings that you want to share with the committee?

AUGUSTINE:

Well, you know, Mr. Chairman, we have all tried very hard to not put you or the president in the position where we come out and endorsed an option, and, you then, if you don't agree with it, have to rebut that. So my answer is that I think I can speak for the committee on options one and two -- we deem to be just not viable.

Of the remaining three primary options, each has some advantages and some disadvantages. The -- and our committee has never discussed what our preferences are. By intent, we have not done that. So I have no idea what my colleagues believe.

I would go so far as to say that these flexible path options are particularly interesting to me (inaudible) because I'm concerned that if we commit to going to the moon, there's a reaction among many -- as a primary objective, many people's reaction is, "Well, we did that years ago, why do that again?"

If we take down the ISS so you don't have things happening between 2015 and 2020, you'd have the problem you just described, Mr. Chairman. And if you say we'll go to Mars right after the moon, there's such a long period of time, that how do you excite young engineers to want to commit their career to that? How do you excite taxpayers to want to pay for that?

And so, to me there's a great merit to having some integral -- excuse me -- interim milestones along the way to Mars. Still going to Mars ultimately, but where you can point to significant technical, engineering, scientific, if you will, advantages and accomplishments.

What I'm saying to be more specific is that clearly option 5 carries that opportunity. Now, you can marry that opportunity with some of the other options as well. And indeed, we've done that with option 5A, for example, which ties in to a version of the Ares V.

NELSON:

At the end of October this year, NASA is well on the way to doing a full-up flight test of the Ares I, what they call X. And, what is the four segments of existing solid rocket boosters with a dummy fifth segment on the top, with a dummy Orion on the top. And to fly it, see its dynamics, the avionics, et cetera.

Did your committee any attitude about that particular test that's right down the pike less than six weeks away?

AUGUSTINE:

The committee did not discuss that. I did discuss it myself with the administrator of NASA, and it is of course his call to make. And I have enormous respect for his ability and judgment.

Were it my call I'd fly it. And the reason is that I think we'll learn important technical -- we'll gain technical knowledge that we've paid a great deal to get and we should get it.

And if we continue with the Ares I program it's an important step. But if we don't continue with it, it's an important piece of information to have as it relates to Ares V and other possible options.

It's our committee's view that the Ares I, while it has technical problems, some not insignificant, there's no reason to believe that good engineering and sufficient funds won't make the Ares I a very good vehicle in time.

NELSON:

Let's talk about my third major category that I think that the president, in making his decision, is going to have to look to, and that is how is he going to keep this extraordinarily talented workforce operating. Share with us what your committee deliberated about that.

AUGUSTINE:

That's a very key part of this whole question. Needless to say, this is a rather esoteric business. And it takes years, as I've observed, to begin to understand some of the subtleties and to gain the culture that goes with launching rockets. One of the reasons being that this is such an unforgiving business. We generally don't get recalls in this business.

NASA has, without question, the largest talent base in the world today to conduct space activities, both human and robotic. That's a national treasure to us. The options we've offered beyond the two that I suggested are probably not viable; all have about the same -- well, they have the same overall budget. And unless one makes a major shift in how one conducts business, the overall NASA employment should stay about the same.

However, the mix of that employment will certainly change. We'll need different talents. For example, if we terminate the shuttle in 2010 or early 2011, the people who have been focusing on launching shuttles are very different people probably than some that will be needed to build an Ares or Ares I or an Ares V or whatever, a shuttle drive vehicle. So there will be changes in skill.

We looked at two kinds of asset (inaudible) another important subject at this time. On the other hand, it is our view that it will be tragic to view NASA as a jobs program. NASA has so much more to offer than just creating jobs.

The other we looked at are those critical skills that only people at NASA or in the industry are likely to have. Those we think it's very important to preserve. And we need to consciously go out and do that.

The example -- pardon me -- an example would be the large solid segmented solid rocket motors. It's an art as well as a science to build those things safely. And if we lose that capability it will very hard to get back. Ability to work with liquid hydrogen, liquid oxygen -- we would like to see us learn how to do that in space as well as here on earth.

So those special skills we have to find a way to preserve, for sure.

And I guess, Mr. Chairman, if I could extend your question just a little bit. One last comment. That would be that NASA has, as I said before, has a very high fixed cost base. It makes it extremely hard to create new opportunities and options when you have that fixed cost base.

And part of that fixed cost base is the centers, the workforce, the facilities. And it would be our hope that the president and the Congress would give the administrator of NASA a great deal of latitude to manage the resources that he's responsible for.

NELSON:

And I want to underscore that comment as a very important comment, so that these dislocations of the workforce, albeit as you said, with the more robust funding, is going to keep NASA at a fairly level amount of employment. That's going to change among the different centers according to what their particular workforce does.

And needless to say, in consideration of if we're not launching humans -- humans on an American vehicle, there's going to be less launches at, for example, the Kennedy Space Center, even though we might be building the new rocket with the new technologies and the new money that you've laid out.

So I hope that the president and the Congress will give the administrator just exactly what you said, the flexibility so that he could utilized that workforce in different places with different missions, so as to minimize the economic devastation.

And, in this regard, I'll put on my parochial hat, because the center that is going to get hit the hardest is the Kennedy Space Center because of the lessening launches of humans.

Now, if indeed for example, that the president were to pick that option of a commercial, that can come in and make some amelioration of that layoff. But it's not -- it's not going to step in. So

we need to give the administrator of NASA a lot of flexibility there. So thank you for that statement.

I want to ask you, what if you had more time? If you had 90 days, if you had more time, do you think the results would change?

AUGUSTINE:

Well, the first thing that would have happened would have been my wife would have divorced me.

(LAUGHTER)

NELSON:

I understand.

AUGUSTINE:

All 10 of us, of course, have regular jobs, so to speak. And when we began I questioned whether 90 days was adequate to take on a task of this type. We clearly could have done a more thorough analysis, given more time. But it's also my belief that if the differences are small between the new options and the current program, we should stick with the current program.

And so, I think we're not discussing small differences, there need to be significant differences. And those of the kinds of things we tried to identify. And our conclusion was that it would have been easier for us and it -- we would have been able to get the third significant figure much more accurately. But in terms of the basic thrust of the options we've offered in our assessment, I think we could stand behind them.

NELSON:

You had testified earlier that your panel's recommendations are, "Don't rush the shuttle flyout. Keep safety paramount," which by the way, parenthetically, I assume will be a theme that will run throughout your report once it is produced publicly; that all of these items, that safety has to be paramount given the experience, a very tragic experience that we've had in the past.

But you indicated in your testimony that you thought that it's realistic to think that at least part, if not all, of fiscal year 2011 would be consumed by the flyout of the shuttle on the remaining missions to supply and equip the space station.

Did you attach a dollar figure to 2011 in that flyout? Since the president's budget right now, and I'll refer it to the OMB budget -- and I say that sarcastically (inaudible) it provides for fiscal year '10 on the flyout of the shuttle. Did you attach a cost to it?

AUGUSTINE:

We did, and we've spoken to OMB about it. And they're aware of the number. And I can't speak for OMB, obviously. My recollection is the number is like \$1.5 billion, but Mr. Chairman, you should check that to be exact.

It's our view that that's very important to add that to the F.Y. 2011 budget. And as you say, it's not there today.

The problem with it not being there is it introduces pressure on getting the launch off by a given time. I referred to that as launch fever, something we always tried to fight at the company I used to serve. It's a subtle pressure. And the Challenger case spoke to that pressure as one of the causes they thought of the Challenger accident.

Having said this, I would hasten to add we've spent a good deal of time with the people responsible for launching the remaining shuttles, the six remaining ones. And they're very conscious of this. They take an attitude that they won't be worried. I think they're doing everything right.

The problem is they're going to run off the budget cliff 12 months from now. And we need to fix that for them. And I think we do, they'll manage things very properly.

NELSON:

And, I have been amazed as I have watched this entire space team, knowing that the space shuttle is likely to come to an end, and they haven't missed a beat -- with still high morale. I mean, to me, I am just -- I'm just amazed and very appreciative.

AUGUSTINE:

I say too, I never cease to be amazed. When having to close a plant, terminate a program, of the commitment of the people to doing just what you said. And that's particularly true in the space arena and the defense arena, where what they're doing is more than building widgets.

NELSON:

That's correct. And I might say, thank you for putting that on the record. I think it's important that the White House and OMB hear what you just said. The Congress has provided in

its budget for the out-year 2011 an additional budget authorization of \$2.5 billion in order to fly out the space shuttle in year 2011. But that's in a budget planning document. It has to be put into reality, and there's only the White House can do that, with the Congress concurring.

But let me ask you, as you look to the future, do you think -- well, let me ask you: What is your opinion about a constant source of funding and an adherence to a defined plan once the option is chosen as a key success for NASA's future?

AUGUSTINE:

That, clearly, would be a key factor for success, particularly if that number included a reserve to account for the unforeseen -- a reserve in time, reserve in funds, reserve in technology.

It's almost impossible, as you know, to manage a program that goes out to the year 2030 when you don't know what the funding commitment is and when you have (inaudible) the program each year. This is a program that probably involves tens of thousands of contracts and subcontractor agreements. And when you change the budget you have to renegotiate those. Rarely do they go down when you renegotiate, so your total costs go up.

Stability in funding would have an enormously positive impact. Having said that, I also recognize the difficulties that you face in your chair when you don't know that the economy is going to collapse on us a year ago, and that the government's receipts are going to drop. And so it's not clear to me how one can guarantee a program budget for the kind of time period it takes to undertake these major pursuits.

But anything that can be done by the Congress and the White House to put stability in the funding, and to let the NASA leadership know ahead of time what that funding is going to be so that they don't have to guess, would be one of the greatest contributions you could make to the human space flight program, or to any space flight program.

NELSON:

Let's talk about these options in four-A through the bottom, where the crew to low Earth orbit is by the commercial provider instead of a NASA vehicle. You know the history of developing spacecraft. You think that seven years that you really could have one of these commercial operators be able to get a human crew up to the space station?

AUGUSTINE:

I think if you were to have several paths with several operators, several commercial firms, not necessarily only the smaller firms that are very quick on their feet, but also some of the larger more experienced firms that are probably less quick on their feet, but have more scar tissue, I

think if you could have several firms involved through a competition, that the chances would be very good that one would have a success.

I think back to earlier in my career when we had ICBMs as launch vehicles (inaudible) familiar. I speak to the Titan and the Atlas. ICBMs in those days, and I was involved, were designed to reliabilities that don't even approach these reliabilities we talk about today for human-rated vehicles. And yet, we did find a way to -- we called it man-rating in those days, incorrectly -- we did find a way to man-rate those vehicles and to use them in the Gemini and the Mercury program and they performed very well.

And so, there's no fundamental physical reason why this shouldn't be possible, but I would say again it's not without risk. There are backups that one can consider. That is other launch vehicles, including foreign launch vehicles, during that period of time.

NELSON:

And so when it comes to U.S. commercial cargo capability, your committee felt pretty confident of that capability?

AUGUSTINE:

I think that's true, and NASA has of course embraced this idea, provided NASA technical oversight and NASA help, which gives me greater assurance. And these firms have some very talented people, and I think there's every reason to believe that they can be successful.

NELSON:

Do you want to talk to us about the differences between the Ares V heavy (inaudible) as an alternative to an Ares V light?

AUGUSTINE:

I'd be glad to do that. The Ares V of course is part of the current program of record, although unfortunately it's not been able to be funded, because to keep the budget for the Ares I and the Orion unchanged, we've been delayed in starting the Ares V and things that might go with it.

The Ares V light is very similar to the Ares V, but it has less payload capability, and the basic measure, as you know, it's 150 metric tons -- let's see, am I getting mixed -- 140 metric tons, I guess, for the Ares V, and 130 I think for the -- there's about a 20 metric ton difference in terms of payload throwaway.

The Ares V light basically has one less engine, it has half a segment less on the solids, and can be designed to have more margin. And, that's important to us because the Ares V, even today many years from first launch, has very shallow margins. And if there's one thing we've learned I think, is that having margins is the blessing of the space program to be able to de-rate things.

The Ares V would be used in companion with an Ares I. It's referred to by NASA as the Ares 1.5, whereas the Ares V light would be used with another Ares V as its companion.

That also has the advantage you would only have to have spares and launch facilities and so on for one launch vehicle at a time. So you would use two Ares V, which gives you -- my numbers for some reason are escaping me at the moment -- but let me just check.

NELSON:

It's 160 metric tons for the Ares V and for the light it's 143 metric tons.

AUGUSTINE:

That's why I couldn't make it work, thank you. And so, you have 320 metric tons throwaway with the two Ares IV lights, and you have 40 less -- excuse me, you have, well, substantially less throwaway with an Ares I (inaudible) Ares V combination.

So we think there's a good deal of merit to the Ares V light approach. The disadvantage of course is that the Ares I is partly developed and the Ares V is not.

NELSON:

And according to your much more complicated chart, you could have the Ares I -- Ares V light ready to go in the early 2020s, if you went the flexible path, if you went the moon first -- so it'd be the early '20s. Of course, you remember that the president said in the campaign he wanted to be on the moon by 2020. So that's pretty much out the window, according to your panel, isn't it?

AUGUSTINE:

That's true.

NELSON:

So you're talking early '20s you could have Ares V light ready, and you would have a scenario by which you could get Ares V up with a crew and also with a lunar vehicle and do rendezvous perhaps in lunar orbit?

AUGUSTINE:

We're speaking to the larger budget level, of course, so the answer would be yes.

NELSON:

Yes.

Do you want to, for the record, give me any comments about the alternative on the EELVs, the expendable launch vehicles?

AUGUSTINE:

Yes. The expendable launch vehicle family of course is one that's been with us for many years, traces its history to the ICBM programs, in fact, and has been extended by the Department of Defense. And these vehicles have been used in various forms, some not yet in the form of carrying the full throw weight that would be needed for this mission. And the vehicles are proven. They're not human-rated, and they would require additional development.

They offer a legitimate alternative, and they also offer the advantage that the Department of Defense and the intelligence community might find them useful -- and we could have some savings there. That offers the disadvantage of having to coordinate the vehicles coming down the line of who gets what and who get first priority.

But it would be our committee's view that the EELV family is a viable option, worthy of consideration. And we have not attempted to make specific choices here, in part because the -- which would probably create a great deal more analysis than we've done in addition to our not wanting to take a position. It's a choice that good engineering can make.

NELSON:

I'm curious, one of the earlier years of accomplishment is underusing an EELV, going the flexible path, and you're looking at the years 2015, 2016. Can you comment on that?

AUGUSTINE:

Yes, the reason for that of course is that the goal has changed. The goal is a much less demanding one under this flexible path option.

NELSON:

So that would still get you out on things like asteroids or one of the Martian moons utilizing an EELV?

AUGUSTINE:

Upgraded, yes.

NELSON:

And you could do that in the span of 2015, 2016?

AUGUSTINE:

No, no, it would be well beyond that. I, unfortunately, have the numbers here with me, but it would be well beyond that.

NELSON:

OK, I was looking from this complicated chart.

AUGUSTINE:

Yes, I don't have that chart.

NELSON:

Well, under that plan on this same chart, you'd be late 2020s doing actually a landing on the moon?

AUGUSTINE:

That sounds more correct.

NELSON:

Did your committee discuss an Atlas or a Delta on the EELVs?

AUGUSTINE:

We did. They're both certainly plausible candidates.

NELSON:

How did your committee arrive at the cost estimates for the different options?

AUGUSTINE:

The committee, as I mentioned, hired the Aerospace Corporation to assist us in this regard, and we also had a good deal of help from NASA. And, we obtained the NASA estimates that they have and the probabilities of confidence levels that go with them.

The Aerospace Corporation has some models that are based on a large number of prior programs -- I believe it's 77 prior programs, space programs. And those models show correction factors to account for real world experiences, compared with estimates that were made at various points of those programs.

We took the work break -- I should say the Aerospace Corporation -- took the work breakdown structure line by line and considered to what was the maturity of the work under that line item. Is this a component that exists? In which case there is -- the factor they would add was 1.0.

If it was a component that was just beginning, depending on the kind of component average they used a factor of about 1.5. If you go through that whole set of items, their average is about a 1.25 factor they used in estimating costs.

The factors, as I say, weigh in the maturity of the item in question, and so that tends to reduce the factor that was added somewhat more.

NASA has raised the point that they consider that some of these factors, or in fact many of them, were included in their original estimates, and that when Aerospace has taken this step, they've double counted. The Aerospace Corporation and ourselves believes that's not the case. And even if it is the case, it's unlikely that we've been too conservative.

And I'll give you one reason. That if you look at this set of programs that the Aerospace Corporation uses to derive the factors -- I think it's 77 programs -- for the whole set of programs

they have a given factor. If you take only the human space flight programs from that set, you have a factor that's almost twice as great.

And so even if we have double counted, chances are we've double counted by on the order of 10 percent or so. And experience would suggest that that's probably not a bad thing to do.

NELSON:

How do you answer this question, that we've spent \$8 billion thus far on the present architecture, which includes Ares I, and now, we're going to abandon that, having spent \$8 billion?

AUGUSTINE:

My answer is that we have offered a set of five options. We have not suggested abandoning Ares I. Some (inaudible) same thing. We could continue with the space shuttle. We could have ISS longer.

It gets to be a question of if you do all of those things, you just don't get to do some of the things of the future like build an Ares V or a heavy lift vehicle, which is we think is what this nation has badly needed, frankly, since the first of these studies I was involved in and recommended at that time.

So Ares I, in our mind, we haven't recommended that it either be continued or that it be abandoned. If it were to be abandoned, we think that there ought to be compelling reasons to abandon it. One of the strong sentiments I've derived in my career is that constantly changing programs is one of the worst things you can do, and you should only make changes for very compelling reasons.

We have offered the pros and cons, and it's up to the reader to judge what the definition of "compelling" is in their mind. There are liabilities to continuing with the Ares I. One of those liabilities is that under the current program plan, as I mentioned at the outset, we won't even get it until two years after the ISS is at the bottom of the Pacific Ocean, by our estimate.

If we extend the ISS we will only be able to use the Ares I for about three years to support it. Then there won't be that much to do with it, frankly, until we get the Ares V. We'll get the Ares V later, because the money on the Ares I. On the other hand, the Ares I is designed to be probably the most reliable vehicle that's ever been built. And we think that will be the case.

As you say, we've spent \$8 billion on it, and although that's a (inaudible) cost issue, nonetheless we've spent \$8 billion. There are a lot of people working on it. We're getting ready to conduct a test of what one might call a prototype of that vehicle. And it too is a very viable vehicle. So I'd like not to make a choice here, but just to point out the pros and cons.

NELSON:

Well, if the president would pick the option of the Ares V heavy lift or the Ares V light, most certainly going to be able to utilize the technology that you developed for the Ares I, so that you don't lose all the value of that \$8 billion that's already been spent.

Is that what the committee concluded?

AUGUSTINE:

That's absolutely true. And similarly, if you pick another option you can always complete the Ares I by adding money. As I recall, it's a -- you know, again, I don't have my data, but I think it's a \$1.5 billion or so. But pretty soon you add up these things. We tried very hard to scratch for money so that our profile was \$3 billion and not \$6 billion or \$5 billion.

NELSON:

What was the committee's thinking on promoting the development of on-orbit refueling?

AUGUSTINE:

Interesting question. As a matter of fact, Wernher Von Braun, in some of his writings -- you may be familiar with -- pointed to the enormous advantages of on-orbit refueling. And over the years we've had some efforts begun to look at the subject, but it never really carried them to any great fruition, principally for financial reasons, cost reasons.

It's our belief that on-orbit refueling will be a major factor in space exploration one day.

We clearly aren't ready to undertake it today. We just don't know enough. It would be too dangerous. But there's no reason that we know of from an engineering standpoint that one can't do it. We would like to use some of the money that we proposed spending under these options three, four and five to run tests, first on the ground and then in the general vicinity of the ISS of refueling on orbit.

And once that's been done, it could have an (inaudible) in the general vicinity of the ISS. For example, some of the (inaudible) on-orbit shuttle options benefit substantially from on-orbit refueling. So we think it's something that's ready for a major technology today, but not anything further beyond.

NELSON:

Did you have any, in your discussions, any idea of the time in mind as to when we should try to target for on-orbit refueling?

AUGUSTINE:

I'd like to provide that for the record, if I could.

NELSON:

Does any of the staff have any additional questions, or do you want to keep the record open for -- that we will do. We'll keep the record open for any of the members of the committee.

I know Senator Pryor was trying to get here and he was with his father, the former Senator Pryor. So I'm sure he'll have one.

Can you give us an estimate of how much it will cost to continue flying the shuttle until Ares I or a commercial solution is available in that range of 2016-2017?

AUGUSTINE:

Well, that was the...

NELSON:

And, let me just complete the station (ph), because it's one of your options. And that would also support the ISS until 2020 and maintain the development of a heavy lift capability by the early 2020s.

AUGUSTINE:

Well, if you were to continue the shuttle to support the ISS through 2020, ...

NELSON:

That's right.

AUGUSTINE:

... you would probably have to add -- I think that...

NELSON:

Just until a new commercial human-rated vehicle would be developed?

AUGUSTINE:

Human-rated, of course.

NELSON:

That -- THAT doesn't seem to be one of the options.

Yes, what staff is pointing out, it'd be the best of all worlds. You continue to fly the shuttle, and the question is what is it going to cost? Until you had a human-rated capability on commercial, you keep the station up there until 2020, so that we have the value of that. And at the same time, you do your technology development of a heavy lift capability by the early 2020s.

AUGUSTINE:

My estimate would be that the additional cost would be of the order of \$10 billion, probably a little more.

NELSON:

Over that whole time period?

AUGUSTINE:

Yes.

NELSON:

That is above the \$30 billion over that 10-year period, which was the \$3 billion per year?

AUGUSTINE:

Exactly. And so, you'd have to add that or else take it out of the thirty. If you take it out of the 30, you slip the other things that we'd like to be doing. If you did continue the shuttle one

benefit of that, another benefit other than closing the gap, is that it makes the closely derived shuttle vehicle options very much more interesting

Because if you still have the shuttle operating and in production for that period of time, then driving from the external tank and so on becomes a much more plausible option. The difficulty, of course, is that we only have three shuttles left. The launch rate will be very low. And when you go low launch rates, you start worrying about safety.

NELSON:

Well, that would be, then, more like option 5C, flexible path, shuttle derived.

AUGUSTINE:

It would be like that, except in the...

(CROSSTALK)

NELSON:

Except the shuttle life would continue to service the space station until a commercial human capability were ready.

AUGUSTINE:

Yeah, you've described the derivative of option 5C...

NELSON:

Right.

AUGUSTINE:

... where you would continue the shuttle operation.

NELSON:

Right.

Any further questions from the staff?

OK, the record will stay open for a couple of days.

And, again, I want to -- I want to thank you for what you've done. This was very unselfish work.

And I think the president really has a major decision here. And there's nothing like a president making a bold decision to focus the nation on where we ought to be going technologically. And he's at that point.

And you've laid out a lot of parameters for him. And I think it's going to be up to the president. We will certainly advise him, but it's his decision.

And it's at a tough, tough time, because of what we're facing with the budget deficit. Just look at these gyrations that we're going through right now in the Senate Finance Committee trying to come up with a consensus on trying to meet the health care problem straight on.

But I believe the president is a visionary, and I believe that the president is going to make a bold stroke, not unlike President Kennedy -- and he set this nation on a course that was extraordinary. And it is my belief that President Obama will do that.

And so with that optimistic note, thank you, Mr. Augustine.

The hearing's adjourned.

AUGUSTINE:

Thank you, Mr. Chairman.

CQ Transcriptions, Sept. 16, 2009

List of Panel Members and Witnesses

PANEL MEMBERS:

SEN. BILL NELSON, D-FLA. CHAIRMAN

SEN. DANIEL K. INOUE, D-HAWAII

SEN. JOHN KERRY, D-MASS.

SEN. BARBARA BOXER, D-CALIF.

SEN. MARK PRYOR, D-ARK.

SEN. TOM UDALL, D-N.M.

SEN. MARK WARNER, D-VA.

SEN. JOHN D. ROCKEFELLER IV, D-W.VA. EX OFFICIO

SEN. DAVID VITTER, R-LA. RANKING MEMBER

SEN. OLYMPIA J. SNOWE, R-MAINE

SEN. JOHN ENSIGN, R-NEV.

SEN. JOHN THUNE, R-S.D.

SEN. JOHNNY ISAKSON, R-GA.

SEN. MIKE JOHANNIS, R-NEB.

SEN. KAY BAILEY HUTCHISON, R-TEXAS, EX OFFICIO

WITNESSES:

NORMAN AUGUSTINE, CHAIRMAN, NATIONAL AERONAUTICS AND SPACE
ADMINISTRATION, REVIEW OF U.S. HUMAN SPACE FLIGHT PLANS COMMITTEE